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CHARACTERIZATION OF BURROWING NEMATODE RADOPHOLUS SIMILIS (COBB, 1893) THORNE, 1949 FOR REGULATORY PURPOSES

R. P. Esser[1], A. L. Taylor[2], and Q. L. Holdeman[3]

The purpose of this circular is to provide a morphological and physiological characterization of the burrowing nematode for use as a guide for identification or delineation of the species for regulatory purposes.

The burrowing nematode has completely destroyed black pepper plantings in Indonesia, and has caused very large losses to citrus properties, and to the plant nursery industry in Florida. It continues to be a major disease problem for the banana industry in many parts of the world.

HISTORICAL: Cobb (1) in 1893 reported immature females of a nematode in the rootstock, outer sheaths, and adjacent soil of banana plants from Fiji. He named this species Tylenchus granulosus and reported that the male was unknown. He described the species but did not publish an illustration. However, on the next page of the same publication, Cobb refers to illustrations of a male of T. similis but gives neither description nor formula. Its habitat was defined as: "Found about diseased banana plants, Fiji, July, 1891." Cobb (2) in 1909 described and illustrated males and females of Tylenchus biformis from sugarcane in Hawaii but made no reference to his previous publications. In 1915, Cobb (3) returned to the subject after receiving some nematodes collected from bananas in Jamaica. This material was used as the basis for complete descriptions of both males and females of T. similis with illustrations by Mr. W. E. Chambers. Tylenchus similis males from Fiji and T. biformis were included as synonyms, but T. granulosus was not mentioned. In 1932, T. Goodey (5) changed the name T. granulosus to Anguillulina granulosus (Cobb, 1893) and placed it in species inquirendae.

In 1949, Thorne (10) having studied specimens from sugarcane in Hawaii and two females from roots of pepper, Piper nigrum, from the East Indies established a new genus Radopholus, with Tylenchus similis Cobb, 1893 as type species. Thorne did not mention T. granulosus.

In 1953, Suit and DuCharme (8) announced that Radopholus similis (Cobb, 1893) Thorne, 1949 was the cause of a disease of citrus called "spreading decline." The State of Florida immediately took steps to prevent spread of the disease and to eliminate it where possible by eliminating the causal nematode. This involved laws and regulations (Chapter 5B-11) which used the name Radopholus similis (Cobb) Thorne, without dates.

In 1968, Sher (7) revised the genus Radopholus, extending the known range and descriptions of R. similis, and for the first time, identified Tylenchus granulosus Cobb, 1893, as the female of T. similis. Sher suggested: "To preserve the well-known name of an important, widely distributed economic pest, it is necessary to regard T. granulosus as a senior synonym or nomen oblitum (forgotten name)." This action is of doubtful validity under the Rules of Zoological Nomenclature.

[1,2]Nematologist and former Chief of Nematology, respectively, Bureau of Nematology, P. O. Box 1269, Gainesville, FL 32602.

[3]Plant Pathologist, Calif. Dept. Food & Agric., 1220 N St., Sacramento, CA 95814.

Taylor in 1969 (9) redescribed R. similis after studying material that he collected in Fiji from Dwarf Cavendish banana plants which he believed to be the type host of Cobb's material. Sher's conclusion that T. granulosus was indeed the female of T. similis was confirmed by very close agreement between Cobb's formula and the average formula of immature females collected by Taylor in Fiji.

CHARACTERIZATION OF DIMORPHIC SPECIES, RADOPHOLUS SIMILIS (SENSU LATO) WHICH INCLUDES KNOWN PHYSIOLOGICAL RACES, BIOTYPES, PATHOTYPES, AND SIBLING SPECIES:

HISTORICAL NOMENCLATURE	REFERENCE
Radopholus similis (Cobb, 1893) Thorne, 1949	(9)
Tylenchus similis Cobb, 1893	(1)
Tylenchus granulosus Cobb, 1893	(1)
Tylenchus autocaudatus Zimmerman, 1898	(12)
Tylenchus biformis Cobb, 1909	(2)
Anguillulina similis (Cobb, 1893) Goodey, 1932	(2)
Anguillulina granulosa (Cobb, 1893) Goodey, 1932	(5)
Tylenchus (Chitinotylenchus) similis Cobb, 1893	(5)
Tylenchorhynchus similis (Cobb, 1893) Filipjev, 1934	
Tylenchorhynchus autocaudatus (Zimmerman, 1898) Filipjev, 1934	
Bitylenchus granulosus (Cobb, 1893) Filipjev, 1934	
Rotylenchus similis (Cobb, 1893) Filipjev, 1936	
Tetylenchus granulosus (Cobb, 1893) Filipjev, 1936	
Radopholus citrophilus (sibling species) Huettel, Dickson and Kaplan, 1984	(6)

MORPHOMETRICS* (Fig. 1,2) µm

Character	Female	Male
Body length	458 (700)**880	447 (700)
Stylet length	16 (21)	9.9 (16.8)
Female gonad - Anterior	110 - 226	
- Posterior	105 - 270	
Anal body diameter	11 - 21	11 - 15
Excretory pore (distance from head)	62 - 107	76 - 104
Spicule		14 - 25.6
Gubernaculum		7 - 12
Vulva %	46 (59) 62.5	
	RATIOS	
Alpha	20 (26.3) 35	29 (35.7) 44
Beta	3.9 (5.5) 10.5	4.1 (8.3) 10.5
Gamma	8 (8.3) 13	4.8 (8.3) 11.4

*Source Ref. 1, 2, 3, 5, 6, 7, 9, 10, 11, 12

**Figure within parentheses is from the original description

DESCRIPTION: Female (Fig. 1-A-D)

Lips flattish hemispherical (Fig. 1-B), set off slightly or not at all. Three to seven lip annules (8-10 in the original description). Stylet well defined with rounded knobs or knobs bearing a slight anterior projection. Four lateral incisures sometimes incompletely aerolated on tail. Vulva slightly or not at all protuberant (Fig. 1-C). Two ovaries each bearing a spheroid spermatheca sometimes containing rodlike sperm. Metacorpus well developed, elongate to ellipsoidal with a distinct valve (Fig. 1-B,D). Three glandular cells lie on the dorsal side of the body; Thorne (10) described this as a single lobe with 3 nuclei. A hemizonad lies 1-2 um anterior to the excretory pore. The excretory lumen leads into a small, ellipsoidal renette cell on the ventral side of the body.

DESCRIPTION: Male (Fig. 2-A-C)

The knob-shaped head (4.5-5 µm long by 6-8 µm wide) is set off by a definitive constriction (Fig. 2-B). Lateral lips are distinctly smaller. Head annules not observed. Stylet, weakly developed with or without knobs (Fig. 2-B). Four lateral incisures present. Inner incisures faint. Esophagus weakly developed, metacorpal valves absent. Caudal alae pronounced, arising about one body width anterior to the spicule head and extending to about one to two body widths anterior to the tail tip (Fig. 2-A,C). Gubernaculum with small titillae. Spicules dorsally arched.

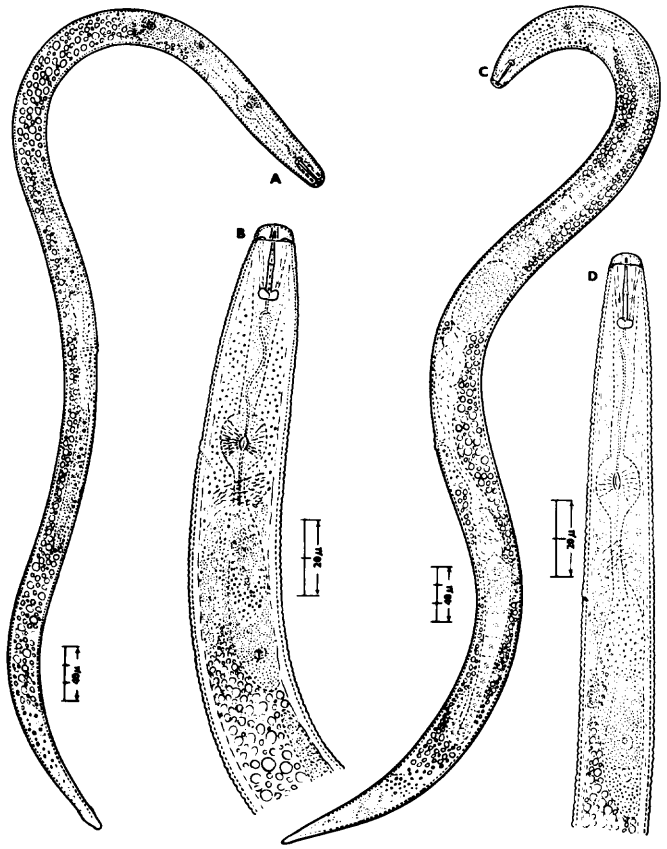

Fig. 1. Radopholus similis females. A) Young female. B) Anterior body of mature female. C) Mature female. D) Anterior body of young female.

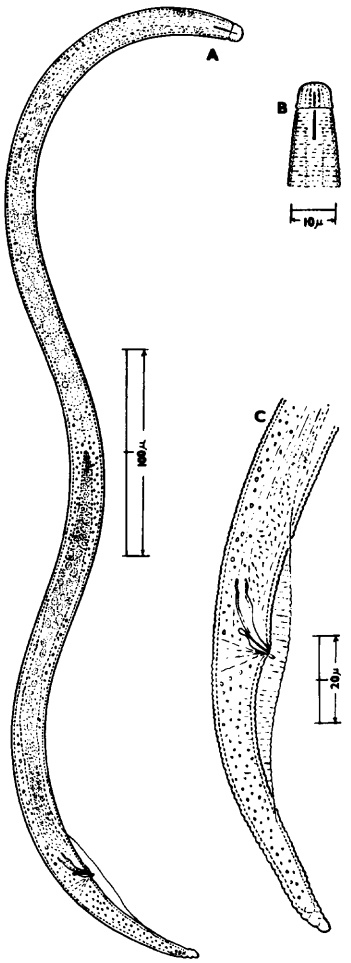

Fig. 2. Radopholus similis male. A) Entire body. B) Head. C) Tail.

PHYSIOLOGICAL RACES AND SIBLING SPECIES

One race parasitizes banana but not citrus, the "banana race"; the other parasitizes both banana and citrus, the "citrus race" (4). Both races, i.e. pathotypes, have extended host ranges that include ornamentals and other food crops. Van Weerdt (12) stated "No significant morphological differences were detected between the progenies of female burrowing nematodes collected from banana and citrus."

Although the citrus race is morphologically indistinguishable from the banana race, it has been proposed that the citrus race be raised to sibling species rank and designated as R. citrophilus (6). The proposed separation is based on observed differences in chromosome number, sexual behavior, host preferences, and body proteins, but not on morphological characteristics.

DISCUSSION: So far as the public good is concerned, the question of races is irrelevant since all races or colonies of Radopholus similis (sensu lato) be they called physiological races, biotypes, pathotypes, or sibling species, are parasitic and are capable of causing economic damage to host plants that are of interest to the agricultural industry. Each country with an economic interest in native host plants that can be severely damaged by races, pathotypes, biotypes, or sibling species of the burrowing nematode will want to continue to protect their agricultural industry through regulation. Radopholus citrophilis has been described but there is no present technology which makes it feasible to identify it in quarantine laboratories. Quarantine samples submitted usually consist of a few live or dead (i.e., preserved), non-gravid females, larvae or males, which are wholly inadequate for laboratory analysis procedures to determine chromosome number, behavioral studies, host testing, or other physiological determinations.

To enable regulatory agencies to continue to offer protection against introduction of burrowing nematodes, a redefinition, for regulatory purposes, is suggested: Pest: all physiological races, biotypes, pathotypes, and sibling species of the burrowing nematode, Radopholus similis (Cobb, 1893) Thorne, 1949 sensu lato.

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